DRIVER OBEDIENCE TO STOP AND SLOW SIGNS

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by
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Jackman

Joint Highway Research Project

PURDUE UNIVERSITY
LAFAYETTE INDIANA

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TO: K. B. Woods, Director
Joint Highway Research Project

March 13, 1956

File: 8-1-2-1-1
C-36-170

FROM: Harold L. Michael, Assistant Director

Attached is a report entitled "Driver Obedience to Stop and Slow Signs" prepared by Mr. William T. Jackman, a member of our staff. Mr. Jackman prepared this report as his thesis for the M.S.C.E. degree under the general direction of Professor Harold L. Michael.

The study provides some interesting information on the characteristics of black-and-yellow versus red-and-white stop signs. It also includes a study of the effect of a speed limit sign in an unwarranted location. Both of the aspects of this study indicate that the installation of signs must be performed wisely if obeyance is expected.

Respectfully submitted,

Harold L Michael

Harold L. Michael, Assistant Director
Joint Highway Research Project

HLM:cjg

Attachment

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Purdue University

Lafayette, Indiana

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ABSTRACT

It was the purpose of this study to determine the effectiveness of stop and slow signs.

The signs used were standard manufactured signs. Four of the stop signs were of the new type, i.e. red and white reflectorized, and the remaining stop sign as well as the slow sign were of the old type, i.e. yellow and black enamel non-reflectorized.

In addition to the slow sign itself, the slow sign study utilized a radar meter and a pneumatic tube speed meter.

The study showed that no combination of stop sign type or position was more effective than any other given the conditions used. However, an attempt was made to weigh the information gathered and assign definite obedience factors to the sign type-position combinations studied.

The study also showed that a slow sign which is placed at a location which obviously does not warrant it is definitely ineffective. This seems to indicate that the average driver is influenced by the apparent factors involved rather than the slow sign itself.

INTRODUCTION

In recent years much attention has been directed to the matter of materials and color combinations of stop signs. Many years back, when the problem first came up, all evidence pointed to an enameled sign with the color combination of black legend on a yellow background. One reason for this was that paints commercially available at the time had inferior qualities compared to present day products. It was felt that the yellow chosen would be the most effective as far as attention getting value, fading of pigment, and distance seen were concerned.

Recently, however, much progress has been made which makes possible reflectorization of signs in a multitude of colors. Also paint pigments are now available which will withstand fading tendencies at least during the average life of a sign (2) (7)*.

The present trend is to a red and white reflectorized stop sign. Red was chosen due to its association with danger by the average person.

This study was undertaken in an attempt to ascertain the effectiveness of reflectorized red and white stop signs, as compared to the standard enameled yellow and black stop sign (3). To put it another way, an hypothesis was set up stating, 'The pattern of response is essentially the same as long as a stop sign is present'. The study was made to test the truth of the hypothesis.

It was understood at the beginning of the study that a stop sign alone would not be the only factor influencing the decision of a driver at a stop situation. Many other factors enter the picture; however, most of them are immeasurable. Some of these are; habit, present

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* Numbers in parentheses refer to the Bibliography

disposition of driver, weather, familiarity with intersection, presence of traffic on cross road, alertness of the driver, individual judgment, newness of sign, and a whole host of others. These factors could be measured only by holding all other factors constant. This alternative, however, would be entirely out of the question, unless some sort of controlled laboratory tests could be arranged.

The experiment was conceived, realizing that many other influencing factors do exist, but with the stop sign and its position as the only controlled variable. It was assumed that the other factors, previously mentioned, would present in an equal degree through out the study.

It is also generally accepted as a fact that motorists do not like to slow down frequently when driving on the rural highways. This idea results in the question of just how effective a slow sign is. This study was initiated in an attempt to ascertain to what extent motorists obey a slow sign. The investigation was constructed so as to limit the reason for slowing down only to the slow sign. This was done by erecting a slow sign where none was needed and studying the results obtained.

It has been said that, "Signs are primarily 'crutches' to compensate for functional errors of design" (5); however, until control of the vehicle can be taken completely away from the driver signs will be necessary. Still it is not a sound engineering or economic principle to erect signs which serve little if any value. This is not to say that no warning of danger be given the driver; but, that if the slow sign must be supplemented by a second sign stating the reason for caution, the slow sign should and could be dispensed with.

PREVIOUS INVESTIGATIONS

Very little work along the lines followed in this study has been reported in the literature available to the author. Wilkie (9) did extensive work on the obedience to existing stop signs which did point out the alarmingly large percentage of stop sign offenders on the roads today.

The actual positioning of stop or slow signs at a particular location has been more or less standardized through the work of the American Association of State Highway Officials (1) and the Bureau of Public Roads (3).

No reference to work done to determine the effectiveness of a slow sign alone could be found in the literature.

PURPOSE AND SCOPE

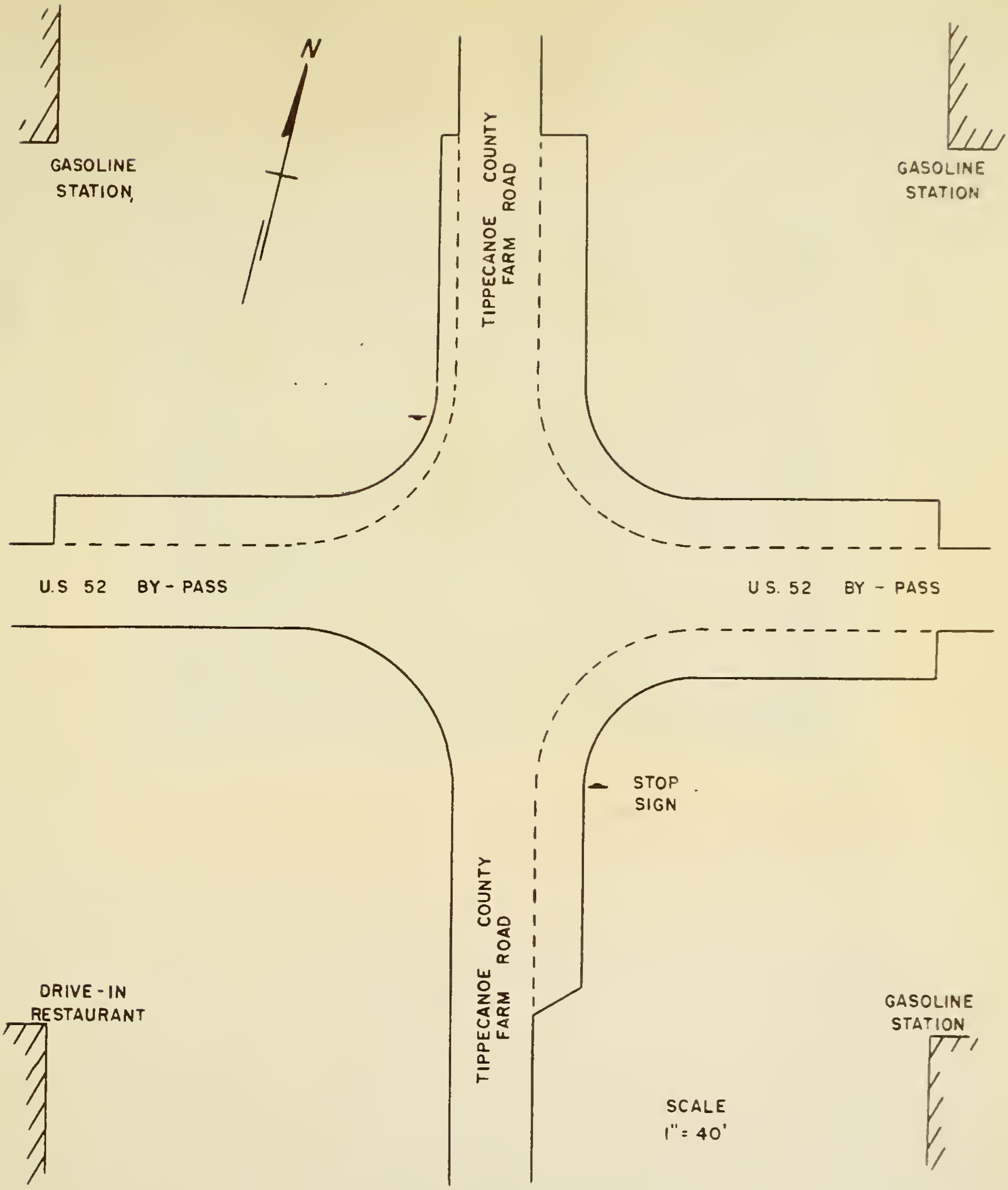
Stop Sign

The purpose of the stop sign study was to measure driver response to a stop sign given certain specified conditions.

Two locations were selected for this study; the intersection of Tippecanoe County Farm Road with US 52 By-Pass (See Figure 1, and Plates I and II) and the intersection of SR 28 with SR 43-US-231 (See Figure 2, and Plates III and IV).

An attempt was made to select locations which were similar in roadside development and topographic features; however, this proved futile since intersections with sufficient volumes to complete the study in the limited period of time available had some sort of signal control governing them. Another factor governing location selection was that each location had to have facilities for parking the observer's car near enough to the intersection to make observation practical without being conspicuous. Because of these factors, the locations chosen were considered fixed rather than random variables in the analysis.

The first location selected was the intersection of Tippecanoe County Farm Road with US 52 By-Pass. During the period of investigation, the drive-in restaurant (on the southwest corner) was closed for repairs and the gasoline station of the northwest corner was under construction and not yet open for business. During construction of the gasoline station on the southeast corner (also the location of the stop sign under consideration), a concrete apron was built completely around the corner giving an extra lane (12 feet) for right turn movements (indicated on Figure 1 by dashed line). The significance of this will

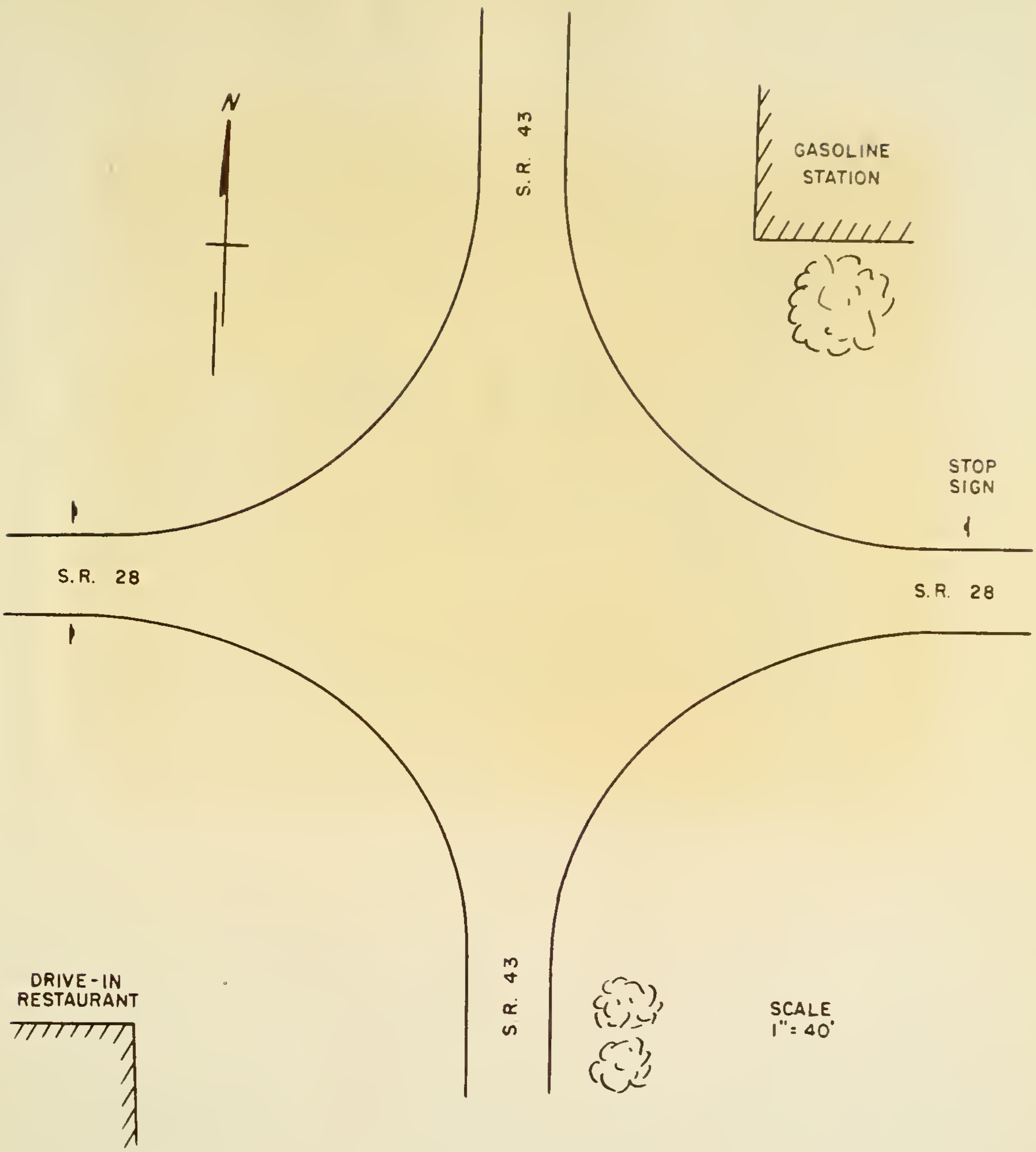


PLAN VIEW
INTERSECTION TIPPECANOE COUNTY FARM ROAD
AND U.S. 52 BY-PASS

FIGURE 1

Plate I Location I - 100 feet from existing stop sign

Plate II Location I - 200 feet from existing stop sign



PLAN VIEW
INTERSECTION S.R. 28 & S.R. 43

FIGURE 2

Plate III Location II - 100 feet from existing stop sign

Plate IV - Location II - 200 feet from existing stop sign

be discussed later. Due to the fact that topography is flat in this area and that the buildings had been set well back from the By-Pass, sight distance was more than adequate up to 100 feet back from the intersection.

The second location selected was the intersection of SR 28 with SR 43-US 231. This intersection was 'wide open', that is, the curves at the corners had large radii, thus, giving a great amount of area within the intersection proper. At times this situation caused much confusion and contributed to one observed near accident. A dip in the road occurs several hundred feet back from the intersection, causing oncoming drivers to lose sight of the main road for a short period. This, along with the vegetation growth on the northwest and southwest sides of the intersection, materially cut down on the available sight distance. Also the main road crosses SR 28 on a slight curve at the intersection.

Observations were made both day and night at both locations. Location I was studied during the latter part of July and the beginning of August, while location II was studied during most of October and the beginning of November.

Both passenger cars and trucks were included in this study. The percentage of trucks at location I was practically negligible while at location II this percentage was rather large. Passenger cars towing trailers or other passenger cars, and farming equipment such as tractors or tractor-drawn wagons were excluded from the study with the idea that the m re makeup of the vehicle would influence driver reaction much more than any of the conditions set.

Pavement width at both locations was 20 feet and in both cases the riding surface was of bituminous material.

Weather conditions were similar during the time of study; that is, observations were made only at times when the pavement was dry and the visibility good.

At both locations a gasoline station was situated on the same corner of the intersection as the stop sign under observance. With the permission of the station operators concerned, the observer's vehicle was parked on the station apron thus allowing it to be inconspicuous, yet close enough for purposes of observation.

Two sign heights were investigated to ascertain their effectiveness. The two heights chosen were three feet, measured from the pavement crown to the bottom of the sign; and five feet, measured in the same way. The first height agrees with the present Indiana standards of 42 inches, measured from the pavement crown to the middle of the sign. And the second height of five feet agrees with the national standards (1) (3).

Slow Sign

The purpose of the slow sign study was to measure driver obedience to a standard slow sign (3).

Two locations were selected for this study; the first was approximately two miles west of the intersection of SR 25 and SR 43-US 231 on SR 25 (See Plates V and VI). The other was approximately one mile west of the intersection of SR 25-US 231 and US 52 (See Plates VII and VIII).

The locations selected were chosen because there was absolutely no warrant for a slow sign. The topography was flat and the grade level;

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Plate V Location I - 100 feet before slow sign

Plate VI Location I - Radar meter as seen from the slow sign

Plate VII Location II - 100 feet before slow sign

Plate VIII Location II - Radar meter as seen from the slow sign

there were no crossings nor entrances warranting lower speeds, and sight distance was much more than adequate.

It should be noted that location I was at a point where the vehicles checked had only traveled approximately 100 yards on a tangent after just having left a gentle, long sweeping curve. Location II was situated so that the vehicles checked had left a 30 mph speed zone approximately 0.5 miles back from the start of the check zone. It was noted in the data that a large majority of the cars checked increased their speed between the two check points at each location. This is probably due to the fact that the locations selected more or less lend themselves to be used as acceleration zones. This situation is not adverse, however, because one must realize that if the slow sign were effective, the vehicle operator would have slowed down regardless of the situation.

Observations were made both day and night at both locations during the latter part of December, 1955 and the beginning of January, 1956.

Only passenger cars were included in the study; trucks, including panels and pickups and farm vehicles were excluded.

Weather conditions were similar during the time of study; that is, observations were made only at times when the pavement was dry, no snow present, and visibility good.

Speeds were taken, using a pneumatic tube speed meter, 700 feet in advance of the sign. Speeds were again taken of the same vehicles, using a commercially built radar meter, 300 feet beyond the sign.

EQUIPMENT

Stop Sign

At the beginning of this study, it was decided that five commercial types of stop signs would be investigated. This decision was influenced by the supply on hand and the different types of stop signs available commercially.

The five sign types included in the group were as follows:

Sign 1 (S_1) - Black enameled message on a yellow enameled background.

Sign 2 (S_2) - The entire sign is covered with a reflective sheeting composed of microscopic spherical lenses with color divisions as follows: silver message and border on a red background.

Sign 3 (S_3) - The entire sign is covered with a smooth surfaced reflective sheeting composed of microscopic semi-spherical lenses with color divisions as follows; silver message and border on a red background.

Sign 4 (S_4) - The entire sign is covered with a semi-plastic pigmented binder into which are embedded microscopic glass spherical lenses of two sizes. The color divisions are as follows; white message and border on a red background.

Sign 5 (S_5) - The sign consists of a white enameled panel and border on a red enameled background. The message is constructed of injection-molded plastic containing microscopic lenses ground in the surface

of the plastic. The figures are covered with a transparent red colored coating on which is sprayed aluminum flake paint.

All five of the signs used were standard 24 inch signs with 8 inch characters (3). Sign 1 was yellow and black enameled while the other four signs were of the newly recommended red and white reflectorized type.

The signs were fastened with two standard bolts and nuts and mounted on a standard metal sign post.

Slow Sign

The equipment used in this study consisted of a standard 30 inch slow sign (black enameled message on a yellow enameled background), a sign post with fasteners, a radar meter, a pneumatic tube speed meter, and a radar meter mount.

The radar meter used (model S-1) was obtained from the Indiana State Highway Department. It was a standard commercial type radar meter of an early design. The principal difference between the motor used and the latest models is that the latest models are more compact and lighter in weight. The method and principles of operation are essentially the same. The accuracy obtainable from the unit was plus or minus 2 mph.

The pneumatic tube speed meter used was the property of Purdue University and is the same one used in practically all of the traffic work done by the Joint Highway Research Project. This meter was designed and built by Campus Electronics at Purdue and works on the principle of the uniform discharging rate of a capacitor. As a vehicle

[illegible]

[illegible]

[illegible]

[illegible]

contacts the first tube, the capacitor starts to discharge at a uniform rate. When the second tube is contacted (at a distance of 88 feet from the first) the discharge is stopped. The amount of discharge is shown on a dial which is calibrated directly in mph.

Speeds on both of the meters used can be read only to the nearest 1 mph.

The radar meter mount (See Figure 3 and Plate IX) was designed and constructed by the author. It consisted of a 10 gallon milk can, half filled with concrete to act as the base. Before pouring the concrete a 4" x 4" wooden post, greased and wrapped in heavy paper, was placed in the milk can. After the concrete hardened this post was removed for easier handling. The post was of such a length so as to bring the top of it to a distance of 4 feet above the ground. A box, constructed of 1/4 inch plywood, measuring 15 inches in length, 15 inches in width, and 8 inches in height was mounted on the top of the post by means of a heavy steel bracket. The box, made to simulate a rural mailbox, was left open at the front to allow interference free operation of the radar unit and was equipped with a removable back for easier handling. A small opening was provided in the back to allow for the passage of the electrical cable of the radar unit.

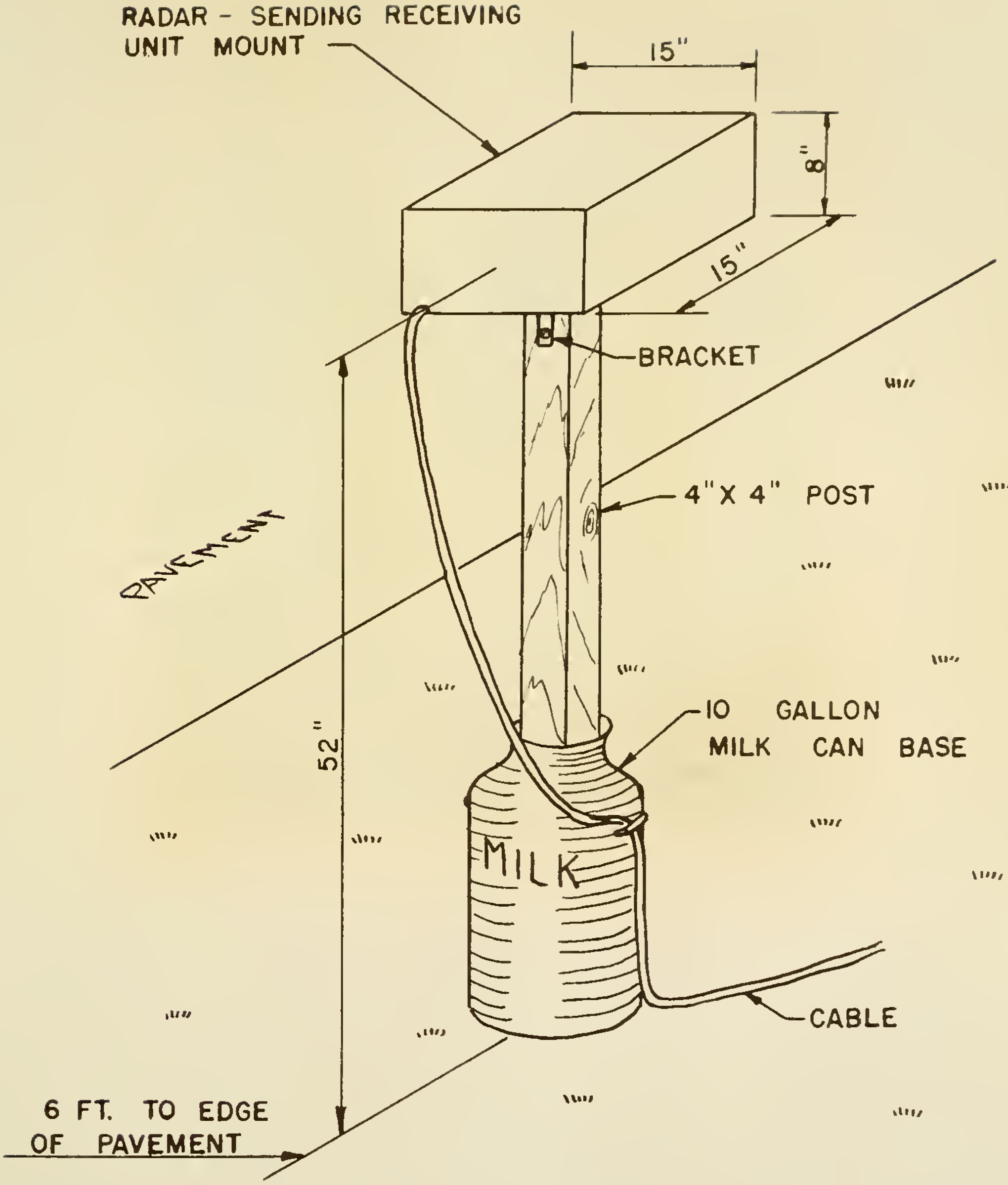


DIAGRAM OF RADAR "MAIL BOX" MOUNT

FIGURE 3

Plate IX Location I - Radar unit in 'milk can' mount

PROCEDURE

Stop Sign

The method of collecting the data entailed placement of one of the stop signs after first removing the existing stop sign or signs and an advance warning sign, depending upon the location. (Location I had but one 24 inch stop sign with no advance warning sign; while location II had two 24 inch stop signs plus an advance warning sign.) The existing signs were removed in an attempt to make conditions as nearly uniform as possible. Permission for removal of these signs, during the period of study, was obtained from the proper authorities in the Indiana State Highway Department.

The sign under study was located approximately one foot in front of the existing sign and at the same distance from the edge of the pavement as that sign. In the case of location I the position was 38 feet from the cross road (US 52 By-Pass) and 3 feet from the curb or 16 feet from the actual pavement edge. The position at location II was 95 feet from the cross road (SR 43-US 231) and 6 feet from the pavement edge.

The individual driver's action at the intersection was recorded under one of three possible classifications; 1) unsatisfactory stop (lowest speed attained by the driver in observing the sign is greater than 5 miles per hour), 2) stopped by traffic (either traffic already at the stop sign or traffic on the cross road), and 3) satisfactory stop (lowest speed attained by the driver in observing the sign is between 0 and 5 miles per hour).

This division of response was decided upon considering the fact

that at a speed of 5 miles per hour or less the driver has his vehicle under control and is capable of making a complete stop with little difficulty, if need be. Also the advent of the automatic shift allows the driver to come to a 'rolling stop' without the necessity of shifting gears. This should not be construed to mean that a 'rolling stop' is legal, it only means that in the opinion of the observer, under the conditions investigated, such a stop is safe. It was also felt that an approach speed of higher than 5 miles per hour was unsafe and, as such, unsatisfactory.

A sample of 50 vehicles was observed for each combination of sign type, sign height, and time (daylight and darkness). As each group of 50 vehicles was observed, the conditions were changed and another group of 50 vehicles observed until a total of 1,000 observations were made at each of the two locations.

Slow Sign

At the beginning of this study some concern was felt as to the effect the tubes of the pneumatic speed meter might have on the driver. To investigate this possibility, two samples, of 50 passenger cars each, were taken, both using the radar meter to measure the speeds. The first sample was taken without the tubes being on the road, the second was taken after the tubes had been positioned on the pavement in such a way that the speeds were taken when the driver was equidistant between the two tubes. It was found that the two average speeds thus obtained were practically identical in magnitude, thus it was decided that for purposes of this test no allowance need be made for the presence of the tubes.

After the position of the speed meter tubes was established, the

slow sign was placed at a distance of 700 feet from a point midway between the two tubes (See Figure 4). A distance of 700 feet was chosen because it was believed that at such a distance a driver would not be able to distinguish the slow sign and thus could not yet be influenced by it. The slow sign was placed at this point at a height of 5 feet from the middle of the sign to the ground.

The next question that had to be answered was where, in relation to the slow sign, should the radar meter be placed so as to record the lowest speeds attained by the drivers observed. Obviously this could not be any one point; however, it was hoped that a point could be found at which the average speed of the sample would be at its lowest value.

Due to the fact that the 'mail-box' mount was open at one end and the radar meter could be seen by the drivers, the meter was beamed down the road and speeds were obtained after the vehicle had passed the radar meter.

The range of the radar meter used varied between zero and 150 feet depending upon the angle with the road at which the unit was placed. Therefore, the radar meter was placed successively at distances of 100, 200, and 300 feet beyond the slow sign, and positioned in such a way so that speeds were obtained as the vehicles passed a point 100 feet beyond the radar meter itself. In this way, the speeds of a sample of 50 passenger cars were obtained for each distance of 200, 300, and 400 feet beyond the slow sign. As the distance from the sign increased the average speed was found to increase; however, the total difference in average speed between a point 200 feet from the sign and one 400 feet from the sign was less than 2 mph. This difference in speed was not

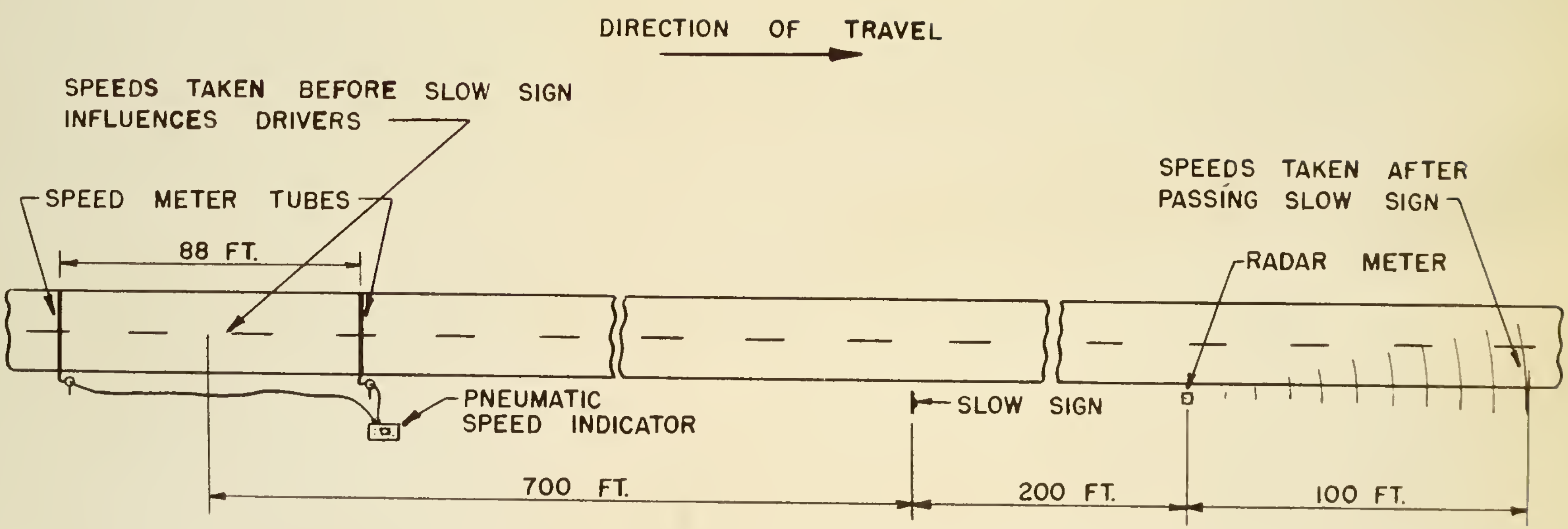


DIAGRAM OF SLOW SIGN SETUP

FIGURE 4

considered to be significant, but since the average speed was increasing, it was decided that speeds would be clocked at a distance of 300 feet beyond the slow sign. This placed the radar unit at a distance of 200 feet beyond the sign.

This investigation was conducted only at location I; however, the distance decided upon was used at both locations.

STATISTICAL ANALYSIS

Stop Sign

General

Upon completion of the field sampling the field data were tabulated into a form which was more easily adapted to analysis. This was accomplished by using frequency distributions of the drivers making either satisfactory or unsatisfactory stops. Those drivers who were in the category of having been stopped by traffic were eliminated because their reaction to the stop sign could not be determined with the procedure used.

Tables 1 and 2 list the distributions used by percentages for both locations and all of the studied conditions. The values obtained were transformed using the arc sin transformation scheme so as to insure homogeneity of variance and thus give more foundation to the analysis and the conclusions drawn.

Frequency polygons for the percentage of vehicles observed and their respective arc sin transformation values versus the sign type, were plotted for both locations, both time periods, both positions, and type of stop made (See Figures 5, 6, 7, and 8).

Study of Variance

To determine what effect the studied conditions had on driver obedience, an analysis of variance was carried out on the sample values. These were transformed to obtain homogeneity by replacing each sample value by its arc sin value (4) (8).

Table 1

FREQUENCY DISTRIBUTIONS OF STOPS MADE AT LOCATION 1

Unsatisfactory Stops

	Position 1		Day	Position 2	
Sign	Percentage	Arc Sin		Percentage	Arc Sin
S_1	14	.7670		12	.7075
S_2	12	.7075		28	1.1152
S_3	8	.5735		24	1.0239
S_4	12	.7075		14	.7670
S_5	2	.2838		30	1.1593
			Night		
S_1	10	.6435		8	.5735
S_2	23.1	1.0025		12	.7075
S_3	16	.8230		8	.5735
S_4	14	.7670		20	.9273
S_5	16	.8230		14	.7670

Satisfactory Stops

	Position 1		Day	Position 2	
Sign	Percentage	Arc Sin		Percentage	Arc Sin
S_1	28	1.1152		56	1.6911
S_2	52	1.6108		40	1.3694
S_3	52	1.6108		38	1.3284
S_4	38	1.3284		54	1.6509
S_5	40	1.3694		32	1.2025
			Night		
S_1	36	1.2870		32	1.2025
S_2	41.4	1.3979		30	1.1593
S_3	50	1.5708		30	1.1593
S_4	50	1.5708		46	1.4907
S_5	38	1.3284		26	1.0701

Table 2

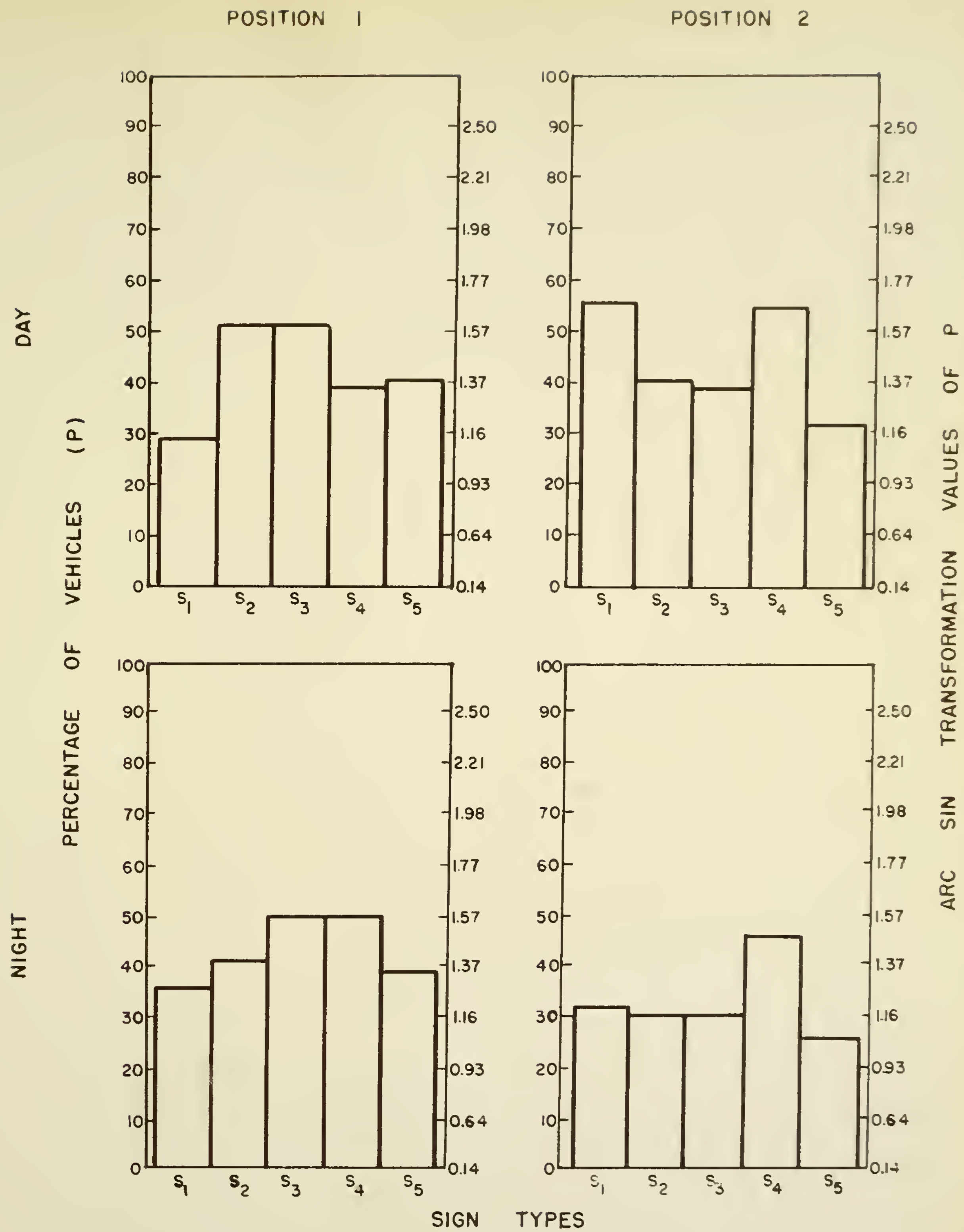
FREQUENCY DISTRIBUTIONS OF STOPS MADE AT LOCATION II

Unsatisfactory Stops

	Position 1		Day	Position 2	
Sign	Percentage	Arc Sin		Percentage	Arc Sin
S_1	10	.6435		12	.7075
S_2	18	.8763		14	.7670
S_3	14	.7670		10	.6435
S_4	12	.7075		16	.8230
S_5	8	.5735		6	.4949
			Night		
S_1	18	.8763		10	.6435
S_2	18	.8763		4	.4027
S_3	22	.9764		12	.7075
S_4	16	.8230		16	.8230
S_5	8	.5735		14	.7670

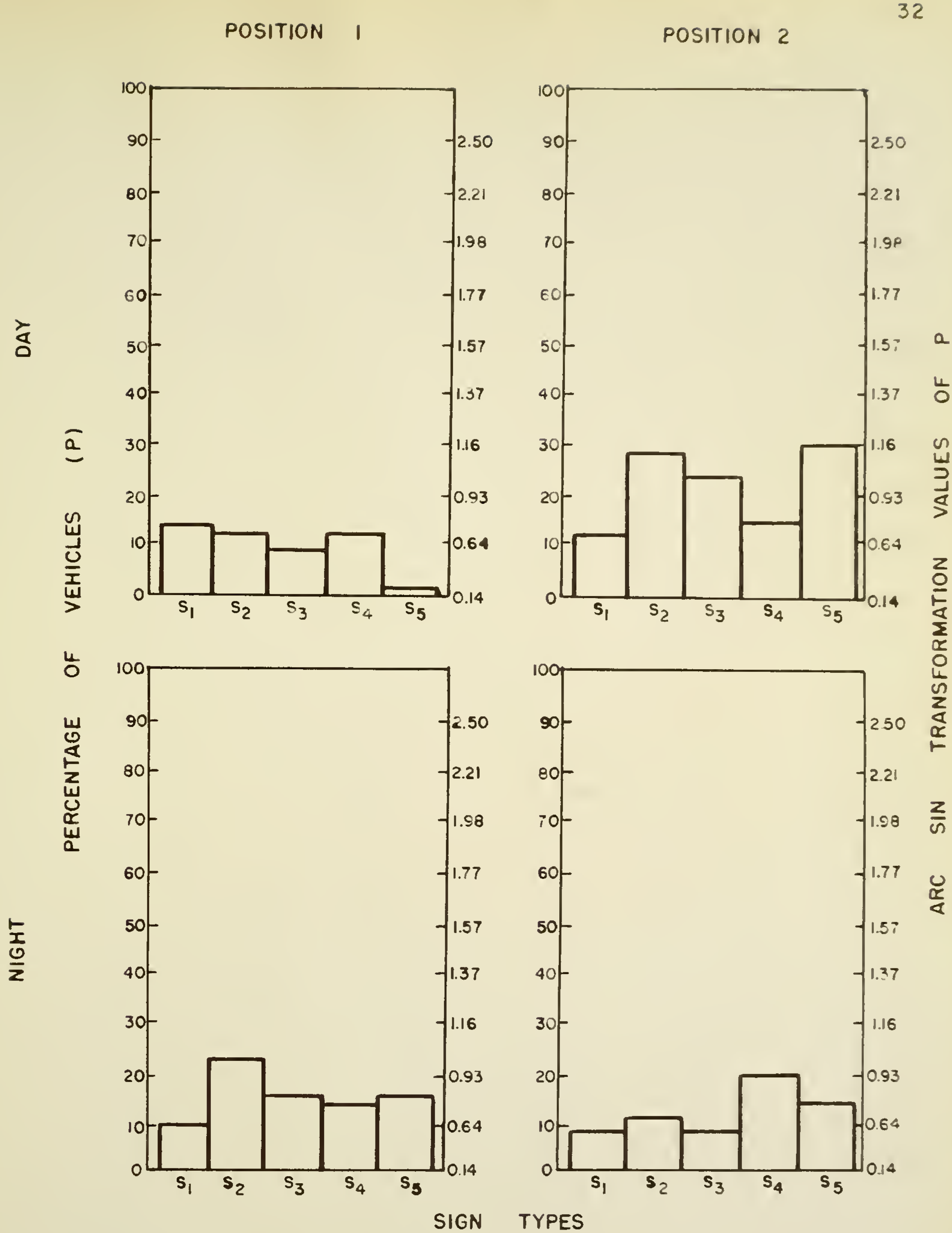
Satisfactory Stops

	Position 1		Day	Position 2	
Sign	Percentage	Arc Sin		Percentage	Arc Sin
S_1	50	1.5708		52	1.6108
S_2	52	1.6108		48	1.5308
S_3	62	1.8132		58	1.7315
S_4	42	1.4101		56	1.6911
S_5	64	1.8546		42	1.4101
			Night		
S_1	62	1.8132		82	2.2653
S_2	56	1.6911		50	1.5708
S_3	48	1.5308		70	1.9823
S_4	76	2.1177		62	1.8132
S_5	42	1.4101		78	2.1652



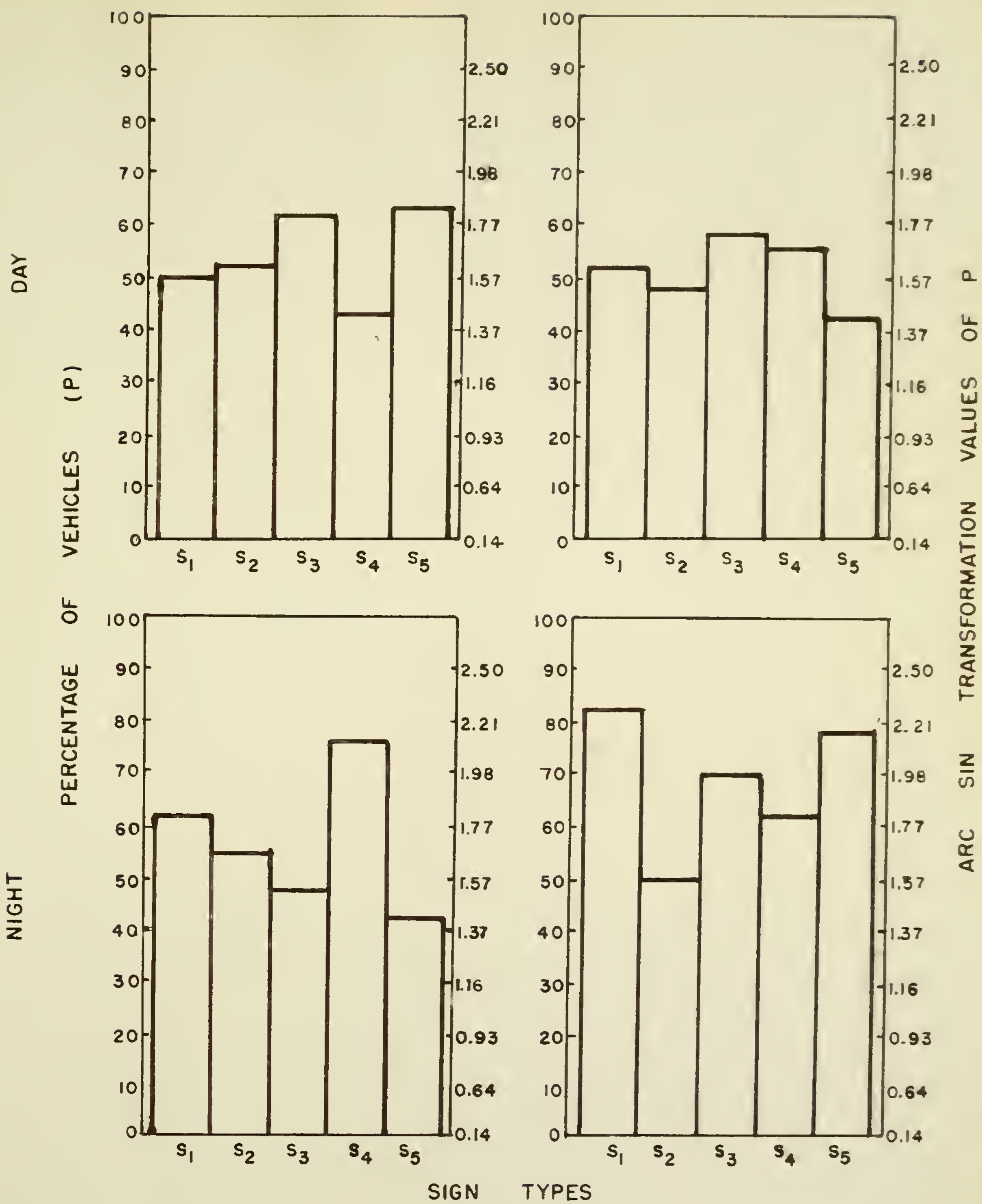
FREQUENCY POLYGONS OF VEHICLES
MAKING SATISFACTORY STOPS AT LOCATION I

FIGURE 5



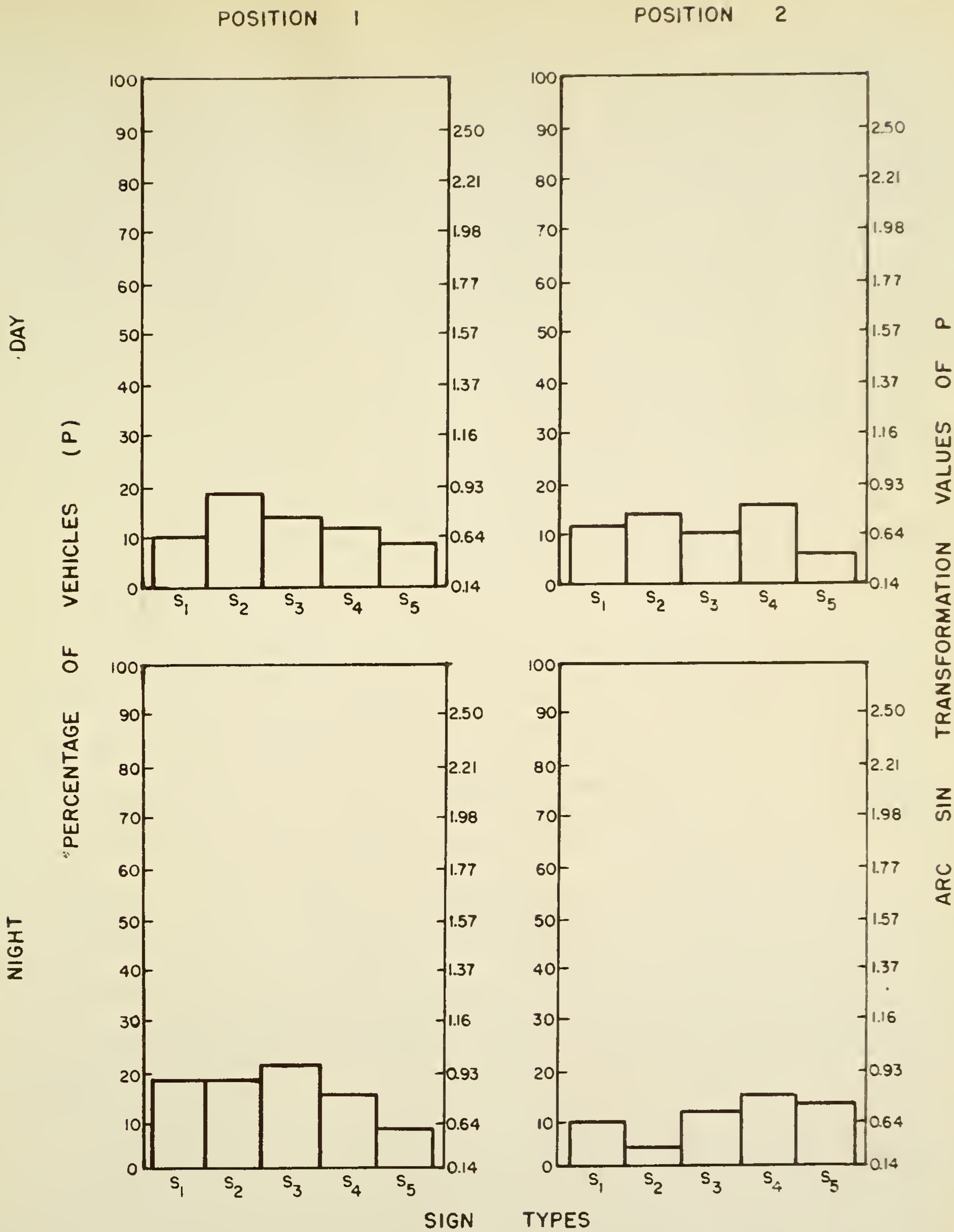
FREQUENCY POLYGONS OF VEHICLES MAKING UNSATISFACTORY STOPS AT LOCATION I

FIGURE 6



FREQUENCY POLYGONS OF VEHICLES
MAKING SATISFACTORY STOPS AT LOCATION II

FIGURE 7



FREQUENCY POLYGONS OF VEHICLES
MAKING UNSATISFACTORY STOPS AT LOCATION II

FIGURE 8

A summary of the analysis of variance carried out on the arc sin values is shown in Tables 3 and 4.

Due to the fact that the locations are considered as fixed locations, the results of the analysis can only be used to reach conclusions about those particular locations and no others. Since this is the case, each source of variation must be compared against the error variance to test for significance.

The results of the analysis of variance indicate that neither the different sign types, their position, the time of day, nor a combination of any two of these had any significant effect on driver behavior at either location. However, the interaction of all three factors proves to be highly significant at both locations.

Since, in a practical sense, it would be impossible to change the sign, its position, or both every twelve hours, the frequency polygons, cited earlier, were summed over day and night (See Figures 9 and 10). This was done in an effort to illustrate the extent of driver obedience to a particular combination of factors during both daylight and darkness. It can be seen from these figures that certain sign types apparently stand out above the others; however, it should be remembered that the analysis shows no significant difference between sign types. Any apparent difference therefore, should be given much thought before being accepted.

It would not do to erect a certain sign expecting a high percentage of satisfactory stops if the percentage of unsatisfactory stops is also high. Therefore, an indicator of sign acceptability was used. This indicator was called R or recommendation criterion. This factor has

Table 3

SUMMARY OF THE ANALYSIS OF VARIANCE

ON ARC SIN VALUES — LOCATION I

Unsatisfactory Stops

Source of Variation	Degrees of Freedom	Mean Square	F(obs.)	Sign.
Sign	3	.0031	1	NS
Time	1	.0002	1	NS
Sign by Time	3	.0015	1	NS
Position	1	.0075	1	NS
Sign by Position	3	.0041	1	NS
Time by Position	1	.0252	1.26	NS
Sign by Time by Position	3	1.1980	59.90	**

Satisfactory Stops

Source of Variation	Degrees of Freedom	Mean Square	F(obs.)	Sign.
Sign	3	.0054	1	NS
Time	1	.0054	1	NS
Sign by Time	3	.0084	1	NS
Position	1	.0037	1	NS
Sign by Position	3	.0087	1	NS
Time by Position	1	.0082	1	NS
Sign by Time by Position	3	3.8100	190.50	**

Notes - - -

NS Factor has no significant effect on driver obedience.

** Factor has a significant effect on driver obedience at the 1% level of significance.

Table 4

SUMMARY OF THE ANALYSIS OF VARIANCE

ON ARC SIN VALUES -- LOCATION II

Unsatisfactory Stops

Source of Variation	Degrees of Freedom	Mean Square	F(obs.)	Sign.
Sign	3	.0030	1	NS
Time	1	.0011	1	NS
Sign by Time	3	.0023	1	NS
Position	1	.0042	1	NS
Sign by Position	3	.0032	1	NS
Time by Position	1	.0021	1	NS
Sign by Time by Position	3	1.0628	53.14	**

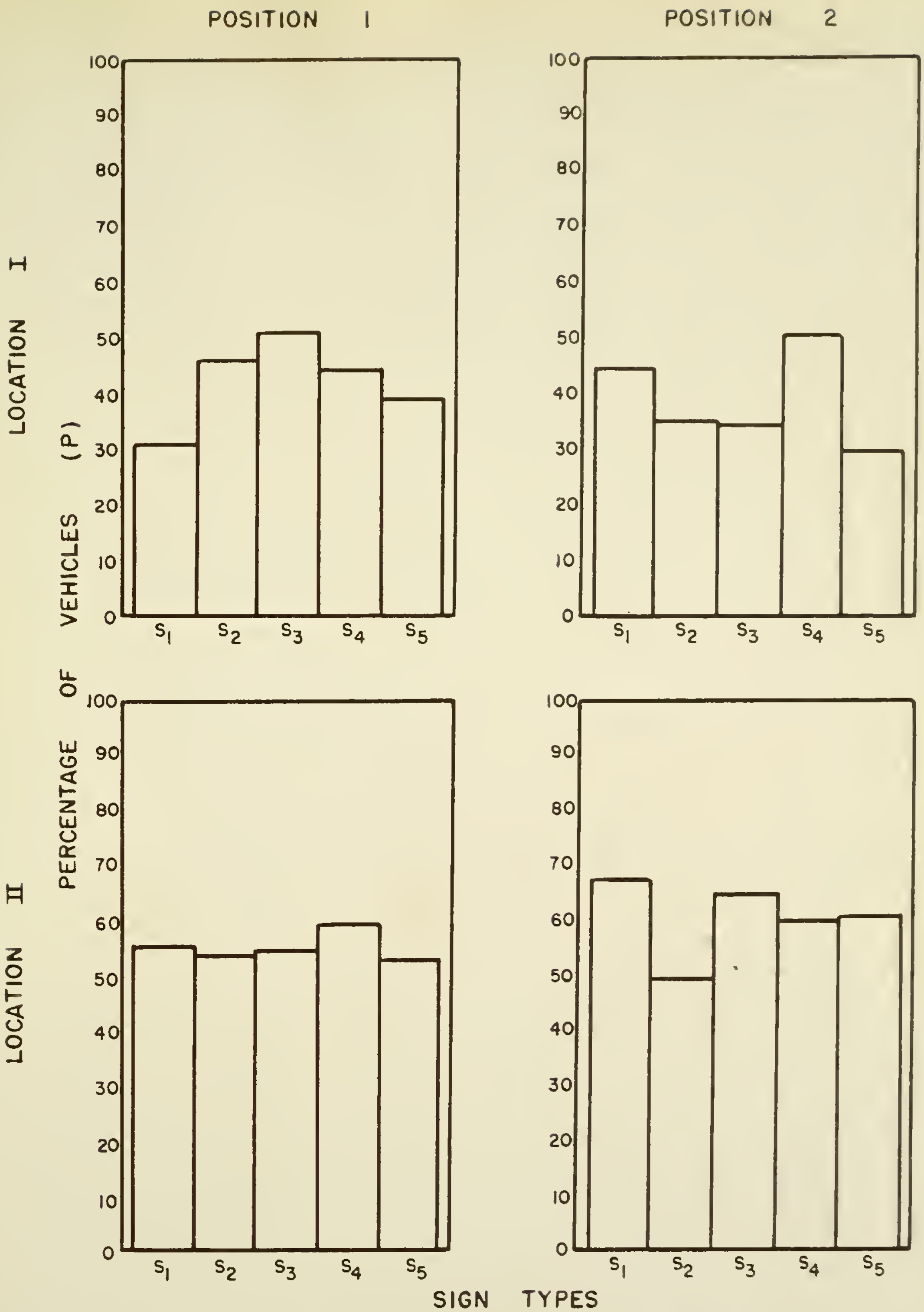
Satisfactory Stops

Source of Variation	Degrees of Freedom	Mean Square	F(obs.)	Sign.
Sign	3	.0035	1	NS
Time	1	.0226	1.13	NS
Sign by Time	3	.0058	1	NS
Position	1	.0045	1	NS
Sign by Position	3	.0028	1	NS
Time by Position	1	.0115	1	NS
Sign by Time by Position	3	8.0024	400.12	**

Notes - - -

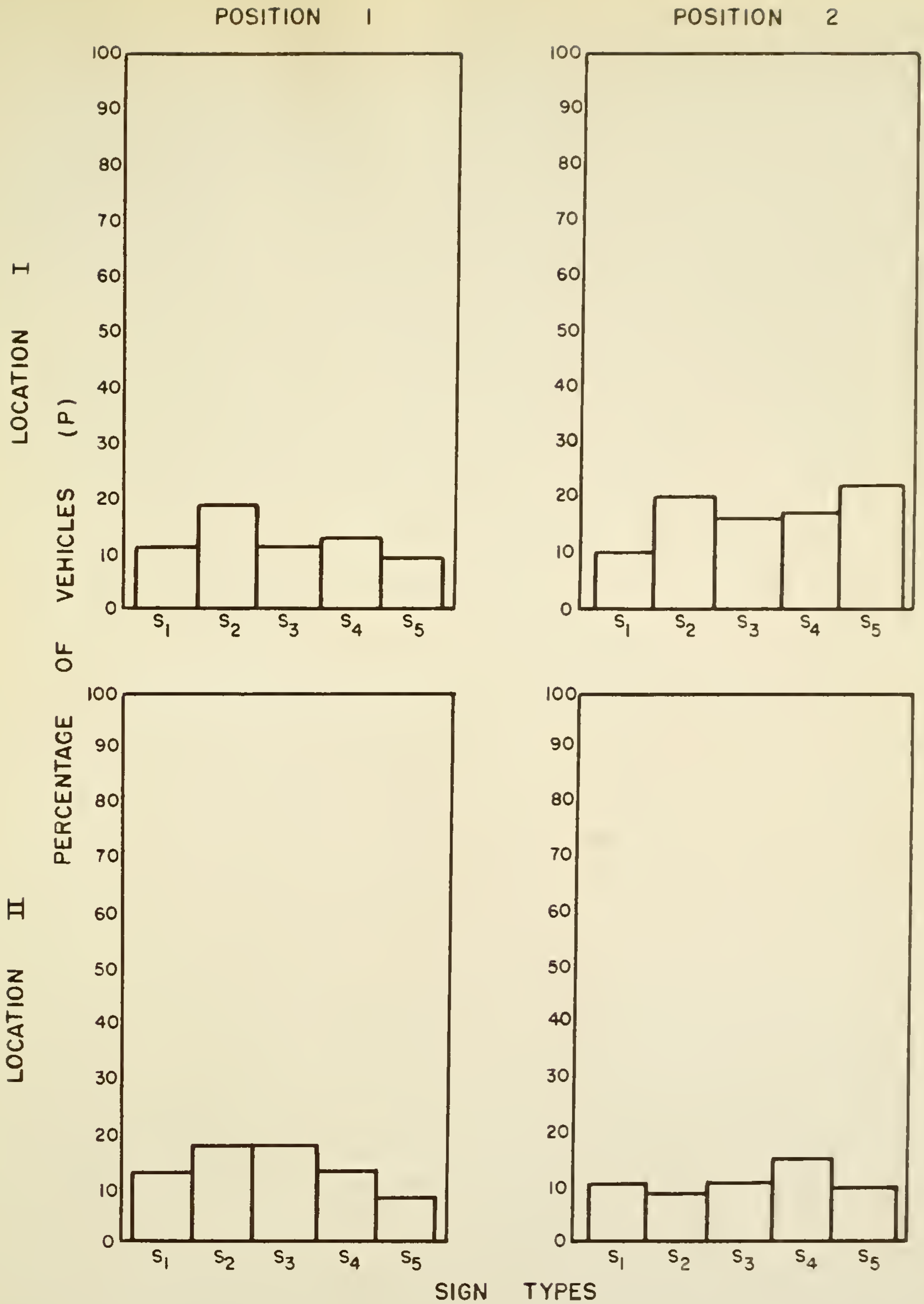
NS Factor has no significant effect on driver obedience.

** Factor has a significant effect on driver obedience at the 1% level of significance.



FREQUENCY POLYGONS OF VEHICLES, SUMMED OVER DAY AND NIGHT, MAKING SATISFACTORY STOPS AT EACH LOCATION

FIGURE 9



FREQUENCY POLYGONS OF VEHICLES, SUMMED OVER DAY AND NIGHT, MAKING UNSATISFACTORY STOPS AT EACH LOCATION

FIGURE 10

the advantage of a higher rate of increase for decreasing values of unsatisfactory stops than for increasing values of satisfactory stops. This is a good feature in that the ratios do not vary proportionately because there is always a certain number of drivers who fall into the classification of having to stop due to existing traffic conditions.

Table 5 shows the number of satisfactory and unsatisfactory stops on the basis of 100 observations per sign, per position, per location. Figure 11 illustrates graphically the use of the R factor for the different sign types by location and position.

Slow Sign

General

Upon completion of the field sampling, the collected data were tabulated in a form more conducive to analysis. This was done by subtracting the final speed from the initial speed. Therefore, a positive difference in speed indicates that the vehicle in question slowed down, while a negative difference indicates a speeding up.

A sample size of 50 passenger cars was used at each of the two locations for each sample taken. A t-test was then run on the collected data to ascertain whether or not this sample size was sufficient for the accuracy desired. It was found that, in each case, a sample size of 50 vehicles was more than adequate to obtain the desired results.

t-Test

It was decided that a one sided t-test would be used to measure the effectiveness of the slow sign (6). To do this a hypothesis was set up which stated that, 'A slow sign alone does influence a driver

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Table 5

NUMBER OF SATISFACTORY AND UNSATISFACTORY STOPS (BASED ON N = 100),

AND R THE RECOMMENDATION CRITERION

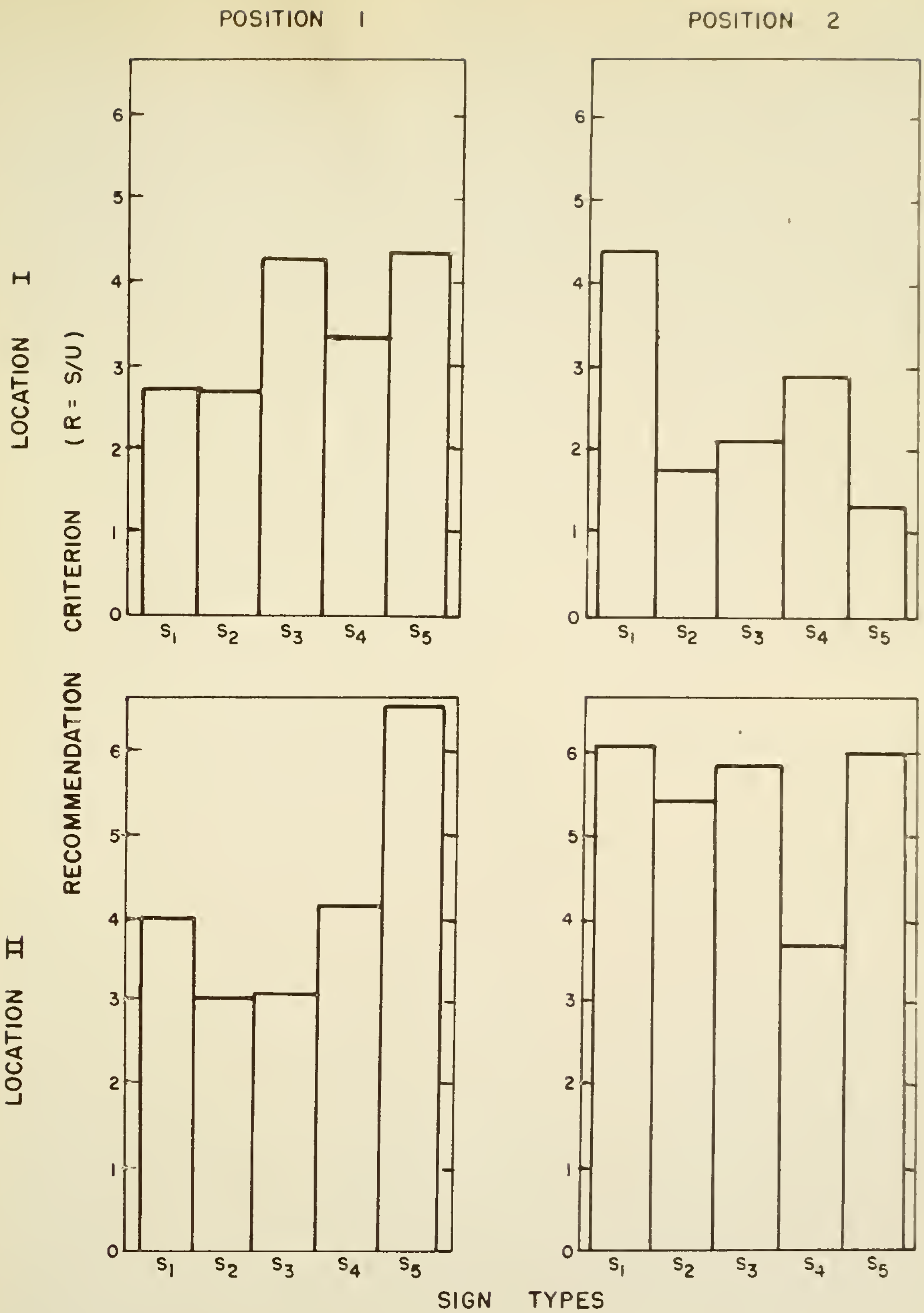
		Position 1		Position 2	
		Loc. I	Loc. II	Loc. I	Loc. II
	S	32	56	44	67
Sign 1	U	12	14	10	11
	R	2.67	4.00	4.40	6.09
	S	47	54	35	49
Sign 2	U	18	18	20	9
	R	2.61	3.00	1.75	5.44
	S	51	55	34	64
Sign 3	U	12	18	16	11
	R	4.25	3.06	2.12	5.82
	S	44	59	50	59
Sign 4	U	13	14	17	16
	R	3.38	4.21	2.94	3.69
	S	39	53	29	60
Sign 5	U	9	8	22	10
	R	4.33	6.62	1.32	6.00

Notes - - -

S Satisfactory Stops

U Unsatisfactory Stops

R Recommendation Criterion (S/U)



RECOMMENDATION CRITERION FOR SIGN TYPES BY POSITION AND LOCATION

FIGURE 11

sufficiently to make him decrease his speed; that is, it is effective'. The alternate hypothesis to this is that, 'The slow sign is not effective'.

By effective, in the hypothesis, is meant that if the true mean of the speed difference (average difference for an extremely large number of drivers) was greater than zero, the slow sign would be defined as being effective. On the other hand, if the true mean of the speed difference was equal to or less than zero, the slow sign would be defined as not effective.

In this type of analysis, the error which is guarded against is the error of saying that the sign in question is not effective when in reality it is effective. With this idea in mind, the tests were designed so as to limit the probability of this error to 5 percent for each of the tests.

Table 6 gives the results of the six t-tests conducted on the collected data, plus the average speed observed for each sample. It can be seen that in four of the six cases the test indicates that the slow sign is not effective. If the slow signs were effective the probability of getting six samples, by chance, which gave four or more significances would be extremely small. Therefore, the conclusion drawn is that the slow signs are generally not effective and no further statistical work on this data is appropriate. The only conclusion which can be reached about the remaining two cases is that; even though it cannot be said, by this test, that the slow sign was not effective the value of $\bar{d}$ is not of great enough magnitude to warrant any opposite conclusion.

This difference in significance might have come about from the fact

Table 6

RESULTS OF t-TESTS AND AVERAGE SPEED FOR EACH SAMPLE

Location I

Sample Size	Average Speed (mph)	Sample Mean	Standard Deviation	Sign.
		(Day 1st sample)		
50	44.3	-1.84	3.512	*
		(Day 2nd sample)		
50	46.5	-1.64	5.698	*
		(Night)		
50	47.0	-4.08	6.796	*

Location II

Sample Size	Average Speed (mph)	Sample Mean	Standard Deviation	Sign.
		(Day 1st sample)		
50	44.5	+1.00	5.966	NS
		(Day 2nd sample)		
50	44.7	+0.92	5.581	NS
		(Night)		
50	45.7	-1.44	5.814	*

Notes - - -

* Slow sign not effective

NS Difference not significantly negative

that the drivers had a longer period of time in which to obtain their normal driving speed prior to arriving at the studied location.

Any further analysis of these data would only serve to point out how much less effective the slow sign was at one location and time of day than at another. This would be of no practical value and of little, if any, academic value.

SAMPLE ANALYSIS

Location I (Day 1st sample)

To choose a d_o such that,

$$P\left\{\bar{d} < d_o\right\} \leq .05 \qquad \text{when } \delta > 0$$

$\bar{d}$ is the average of $n = 50$ d's (difference in speed) each of which is normal with mean δ and standard deviation σ. Let

$$S = \sqrt{\frac{\Sigma(di-\bar{d})^2}{n}}, \text{ then}$$

$$P\left\{\frac{\bar{d}-\delta}{S/\sqrt{n-1}} < \frac{d_o-\delta}{S/\sqrt{n-1}}\right\} \leq .05 \qquad \text{when } \delta > 0$$

since the largest value of the left side occurs when δ approaches zero ($\delta \rightarrow 0$) a d_o must be chosen so that

$$P\left\{\frac{\bar{d}}{S/\sqrt{n-1}} < \frac{d_o}{S/\sqrt{n-1}}\right\} \leq .05$$

In a one sided t-test, with $\delta = 0$ the term $\frac{\bar{d}}{S/\sqrt{n-1}}$ has a t distribution with n-1 degrees of freedom. In this case the value of $t_{49} = 1.68$. Setting $d_o\sqrt{n-1}/S$ equal to this gives

$$d_o = 1.68 \ S/\sqrt{49}$$

The numerical results for this case are in Table 6, and it can be easily calculated that

$$d_o = 0.84$$

Comparing this value with the value of $\bar{d}$ (in this case $\bar{d}$ equals -1.84) we will conclude that the slow sign is not effective.

CONCLUSIONS AND RECOMMENDATIONS

It is important to remember that the stop sign analysis has been based on data collected at two particular intersections with only a few variables being controlled. Some of the ideas arrived at might have to be qualified by the results of analysis of additional intersections.

Under the conditions presented at the intersections studied, the following conclusion has been reached:

> In general, no combination of stop sign and position is any more effective than another as far as driver obedience is concerned. However, it can be concluded that, using R as a criterion, sign type 1 at position 2 for location I and sign type 5 at position 1 for location II exhibit the highest obedience factor for the particular location. The R value also indicates that sign type 5 is the best at position 1 for both locations and sign type 1 is the best at position 2 for both locations.

It should be noted that the slow sign analysis performed has been based on data collected at locations where the installation of slow signs is not warranted, and where the natural tendency of the driver is to accelerate. Therefore, with this fact in mind, the following conclusions and recommendations have been reached:

1. Slow signs are, in themselves, generally not effective.
2. Slow signs should not be used without additional signs stating the nature of the danger involved. Even then slow signs are probably not warranted unless the need to decrease speed is very great.

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APPENDIX

APPENDIX

Certain traffic behavior patterns were noted at the stop sign locations and the following are comments on these patterns.

1. The existing stop sign at location I should be moved, either closer to the curb or back further from the intersection so that a driver might observe it sooner and not be hindered by the presence of the utility pole.
2. A concerted effort should be made to discourage west bound drivers on US 52 By-Pass, intending to turn left onto Tippecanoe County Farm Road, from crossing over, several hundred feet from the intersection, and using the gasoline station apron as a third lane.
3. The intersection at location II encompasses too much area to function safely. It is used as a turning area for local drivers making U-turns. Also the stop sign is located at too great a distance from the prescribed stop within ten feet of the sign and still have a clear view of approaching traffic on the cross road. It is felt that the intersection should be investigated as to the possibility of installing islands or some other means of decreasing the area involved.